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(57) Abstract

A magnesium alloy having high strength and elongation, comprising, by weight, 5.3 - 10.0 % aluminum, 0.7 - 6.0 % zinc, 0.5 - 5.0 % silicon, 0.15 - 10.0 % calcium, with the substantial balance being magnesium.

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MAGNESIUM ALLOY FOR A HIGH PRESSURE CASTING AND PROCESS FOR THE PREPARATION THEREOF

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a magnesium alloy for a high pressure casting including a process for the preparation thereof, and more particularly, to a magnesium-based alloy containing aluminum, zinc, silicon, etc. in combination with calcium for improving strength and toughness thereof. Advantageously, the alloy of the present invetion is used in a die-casting or a squeeze-casting process.

Description of the Related Art

Various types of magnesium-based alloys are known in the art. Generally, the magnesium-based alloys possess excellent strength and are light alloys used for regular casting and a high pressure casting. Accordingly, the products made with the magnesium-based alloys have been used in automobile parts and airplane parts.

Such conventional magnesium-based alloys contain, for example, 8.3 - 9.7 weight percent (hereinafter "W%") of aluminum, 0.35 - 1.0 W% of zinc, less than 0.15 W% of manganese, below 0.1 W% of silicon, and the remainder being magnesium; 5.5 - 6.5 W% of aluminum, less than 0.22 W% of zinc, greater than 0 - 13 W% of manganese, less than 0.5 W% of silicon, and the remainder being magnesium; and 3.5 -5.0 W% of aluminum, less than 0.12 W% of zinc, 0.2 -0.5 W% of manganese, 0.5 - 1.5 W% of silicon, and the remainder being magnesium. Such conventional magnesium-based alloys are satisfied with less than 0.005 W% of iron, less than 0.03 W% of copper, and less than 0.002 W% of nickel.

Also, U.S. Patent 5,078,962 discloses high mechanical strength magnesium alloys and a process for manufacturing the same by rapid solidification and consolidation by drawing generally exceeding 400 or 500 MPa, with an elongation at break of at least 5%. These alloys have a chemical composition of 2 - 11 W% of aluminum, 0 - 12 W% of zinc, 0 - 1 W% of manganese, and 0.1 - 4 W% of rare earth elements with the main impurities and residue being magnesium.

However, these conventional magnesium-based alloys suffer from a number of problems such as, for example, they gave a low strength when subjected to high elongation, they have a low elongation if they have high strength, and thus they do not have high strength and elongation.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved magnesium alloy for high pressure casting and a process for the manufacture thereof, which eliminates the above problems encountered with respect to conventional magnesium alloys and their processes.

Another object of the present invention is to provide a magnesium alloy comprising 5.3 - 10.0 W% of aluminum, 0.7 - 0.6 W% of zinc, 0.5 - 5,0 W% of silicon, and 0.15 - 10.0 W% of calcium, and with the substantial balance being magnesium, possessing high strength and toughness for die-casting and used in automobile and airplane parts.

A further object of the present invention is to provide a process for the preparation of a magnesium-based alloy which comprises adding 0.5 - 10.0 W% of calcium to an alloy of magnesium, aluminum, zinc and silicon to produce a high strength and tough magnesium alloy by controlling the needle-shaped structure of Mg_2Si.

Other object and further scope of the applicability of the present

invention will become apparent from the detailed description given hereinafter. It should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Briefly described, the present invention relates to a magnesium alloy comprising 5.3 - 10.0 W% of aluminum, 0.7 -6.0 W% of zinc, 0.5 - 5.0 W% of silicon, and 0.15 - 10 W% of calcium, with the substantial balance being magnesium, thereby controlling the needle-shaped structure of Mg_2Si, whereby the magnesium alloy possess high strength, toughness and elongation.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1(A) is a photograph using an optical microscope showing the microstructure of a magnesium alloy with 11 W% of aluminum, according to the present invention;

Fig. 1(B) is a photograph using an optical microscope showing the microstructure of a magnesium alloy with 7 W% of aluminum, according to the present invention;

Fig. 1(C) is a photograph using an optical microscope showing the microstructure of a magnesium alloy with 4 W% of aluminum, according to the present invention;

Fig. 2(A) is a photograph using an optical microscope, of the

invention will become apparent from the detailed description given hereinafter. It should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Briefly described, the present invention relates to a magnesium alloy comprising 5.3 - 10.0 W% of aluminum, 0.7 -6.0 W% of zinc, 0.5 - 5.0 W% of silicon, and 0.15 - 10 W% of calcium, with the substantial balance being magnesium, thereby controlling the needle-shaped structure of Mg_2Si, whereby the magnesium alloy possess high strength, toughness and elongation.

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Fig. 1(A) is a photograph using an optical microscope showing the micro-structure of a magnesium alloy with 11 W% of aluminum, according to the present invention;

Fig. 1(B) is a photograph using an optical microscope showing the micro-structure of a magnesium alloy with 7 W% of aluminum, according to the present invention;

Fig. 1(C) is a photograph using an optical microscope showing the micro-structure of a magnesium alloy with 4 W% of aluminum, according to the present invention;

Fig. 2(A) is a photograph using an optical microscope, of the

magnesium alloy of 9 W% of aluminum, 1 W% of zinc and 0.7 W% of silicon in a low pressure-casting, according to the present invention;

Fig. 2(B) is a photograph using an optical microscope, of the magnesium alloy of 9 W% of aluminum, 1 W% of zinc and 0.7 W% of silicon in a high pressure-casting, according to the present invention;

Fig. 3 is a front elevational view of a squeeze casting device for casting the magnesium alloy according to the present invention, and

Fig. 4 is a photograph using an optical microscope, of the magnesium alloy according the to present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the drawings for the purpose of illustrating the preferred embodiments of the present invention, the magnesium alloy for high pressure casting and the process for the preparation thereof, as shown in Figs. 1(A) - 1(C) , comprises 5.3 - 10.0 W% of aluminum, 0.7 - 6.0 W% of zinc, 0.5 - 5.0 W% of silicon, and 0.15 - 10.0 W% of calcium, and preferably adding 0.5 - 10.0 W% of calcium to the magnesium-based alloy of aluminum, zinc, and silicon.

When 0.5 - 10.0 W% of calcium is added to an alloy of magnesium, aluminum, zinc, and silicon, the present magnesium alloy has high strength and toughness. The presence of calcium controls the micro-structure of the magnesium alloy, and prevents a decrease in strength due to formation of the needle-shaped structure of Mg_2Si.

As shown in Fig. 1(A), if the amount of aluminum is 11 W% based on the entire amount of the magnesium alloy, the magnesium alloy of the present invention exhibits a spherule micro-structure. These spherule micro-structure products are very stable structures with an excellent elongation. However, the spherule structure is fully distributed in the magnesium alloy, so that the

strength thereof is low.

As shown in Figs. 1(B) and 1(C), if the amount of aluminum is below 4 W%, the magnesium alloy of the present invention has a needle-shaped structure. Such a needle-shaped structure has a little elongation but has a high strength. The addition of calcium controls the disadvantages of Mg_2Si in a needle-shaped structure and in a small amount of aluminum. The presence of calcium converts the needle-shaped structure to a spherule structure.

Accordingly, the present invention is characterized by the addition of 0.15 - 10.0 W% calcium to the magnesium alloy. If the amount of calcium is less than 0.15 W%, the desired effect cannot be expected. If the amount of calcium is above 10.0%, this amount is greater than the amount of aluminum in the main dispersoid ($Mg_{17}Al_{12}$), such that the role of calcium is diminished.

Also, the magnesium alloy of the present invention is characterized by a specific ratio of all of the constituents. The range of 5.3 - 10.0 W% of aluminum has the role of making the dispersoid ($Mg_{17}Al_{12}$). If the amount of aluminum is over 10.0 W%, there is the problem of producing the spherule structure of Mg_2Si. If the amount of zinc exceeds 6.0 W%, a hot crack is created. Silicon has the role of making a second dispersoid (Mg_2Si). If the amount of silicon is below 0.5 W%, Mg_2Si is precipitated in only a small amount, and if the amount of silicon is over 5.0 W%, the resulting magnesium alloy has a decrease in its resistant-collision property.

The magnesium alloy of the present invention is utilized with high pressure casting such as die-casting or a squeeze-casting process (Fig. 3). If the magnesium alloy of the present invention is utilized with low pressure casting, Mg_2si does not form a needle-shaped structure, and the alloy has a low strength due to the production of regular or silicon crystals.

An optical microscope is used to analyze each micro-structure of

products by using gravity casting as shown in Fig. 3(A), and high pressure casting, as shown in Fig. 3(B). That is, the magnesium alloy (Fig. 3(B)) casted by high pressure casting exhibits higher strength and excellent elongation when compared with a magnesium alloy (Fig. 3(A)) casted by low pressure casting.

The present invention will now be described in more detail in connection with the following examples which should be considered as being exemplary and not limiting the present invention.

Example and Comparative Example

The following magnesium alloys are made using the following ratio of metals alloyed together and the tensile strength, yield strength and elongation are measure and recorded in Table I.

Table I

	Example	Comparative Example 1	Comparative Example 2
Aluminum	5.0	9	5
Zinc	1.0	1	1
Silicon	0.7	0	0.7
Calcium	0.2	0	0
Magnesium	Remainder	Remainder	Remainder
Tensile Strength (MPa)	213	193	194
Yield Strength (MPa)	116	114	115
Elongation (%)	7.6	4.3	5.6

As shown in Table I, a magnesium alloy containing calcium according to

the present invention possesses excellent high tensile strength, yield strength and elongation.

Experimental Example

The magnesium alloy of the above example is observed using an optical microscope and the results of the observation are shown in Fig. 4. That is, in the magnesium alloy according to the present invention, there is formed $Mg_{17}Al_{12}$ as a spherule structure as shown in (a) of Fig. 4.

Mg_2Si as a spherule structure is converted from a needle-shaped structure as shown in (b) of Fig. 4.

Accordingly, the magnesium alloy according to the present invention has a high strength and toughness, and is effectively utilized with the high pressure casting such as die-casting or squeeze-casting in order to maintain the above high strength and toughness thereof.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included in the scope of the following claims.

WHAT IS CLAIMED IS

1. A magnesium alloy having high strength an elongation, comprising, by weight, 5.3 - 10.0% aluminum, 0.7 - 6.0% zinc, 0.5 - 5.0% silicon, 0.15 - 10.0%, calcium, with the substantial balance being magnesium.

2. The magnesium alloy of claim 1, wherein said alloy is cast by a high pressure casting procedure.

3. The magnesium alloy of claim 2, wherein said high pressure casting procedure is die-casting.

4. The magnesium alloy of claim 2, wherein said high pressure casting procedure is squeeze-casting.

5. A process for the preparation of a magnesium alloy having high strength and elongation, which comprises casting a magnesium-based alloy containing aluminum, zinc, and silicon, and adding thereto calcium in an amount of 0.15 - 10.0% by weight percent.

6. An automobile or airplane part made of a magnesium alloy comprising, by weight, 5.3 - 10.0% aluminum, 0.7 - 6.0% zinc, 0.5 - 5.0% silicon, 0.15 -10.% calcium, with the substantial balance being magnesium.

Fig. 1 (C)

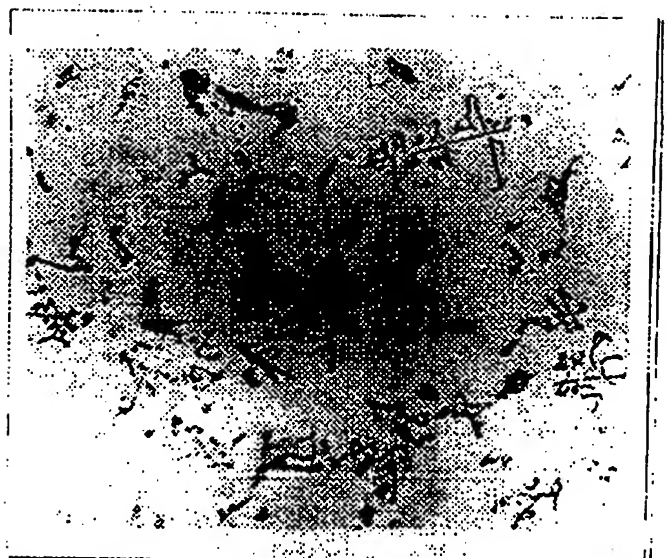


Fig. 1 (B)

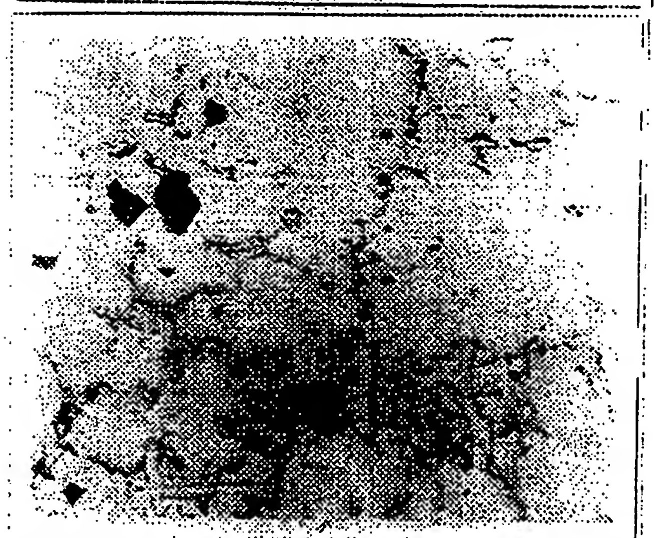


Fig. 1 (A)

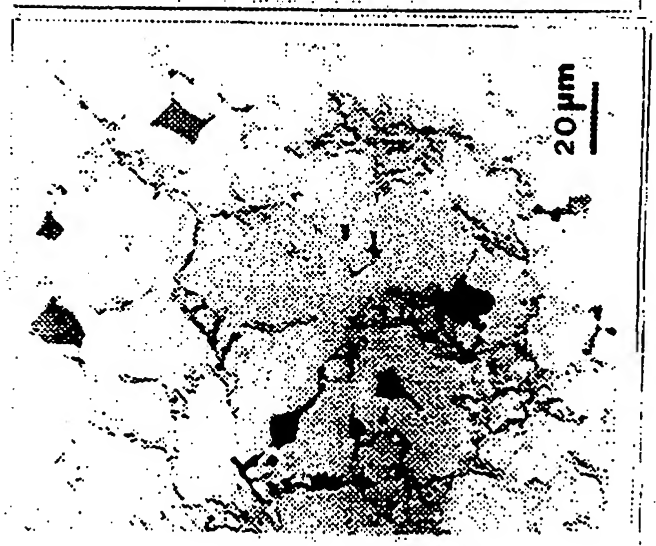
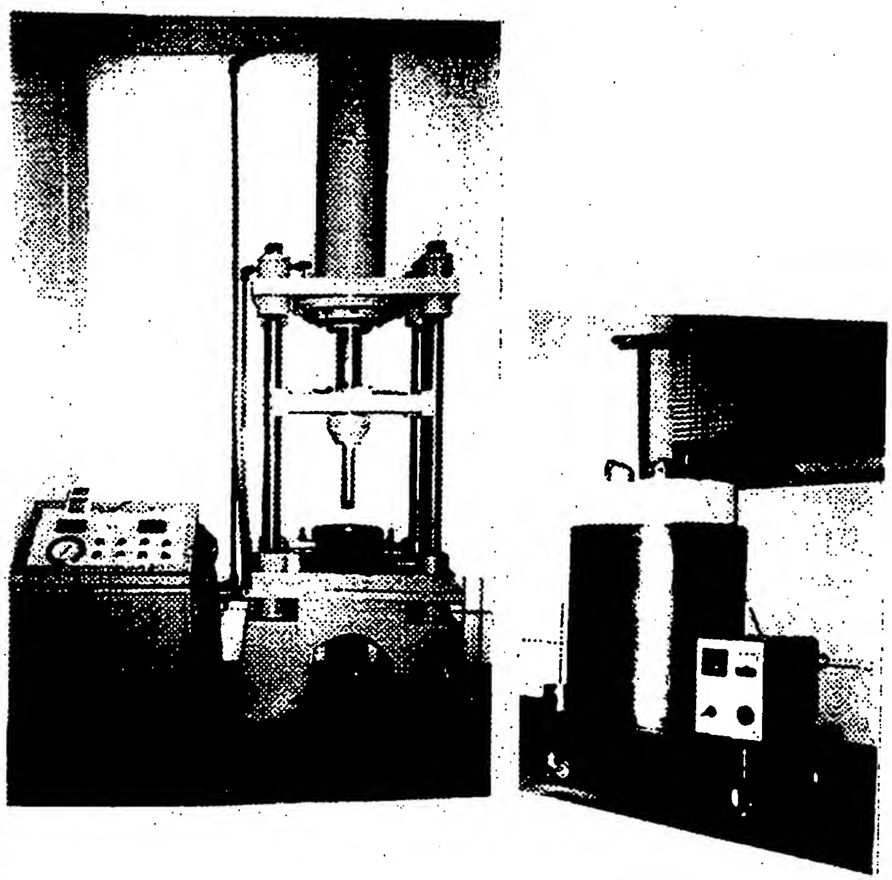


Fig. 2



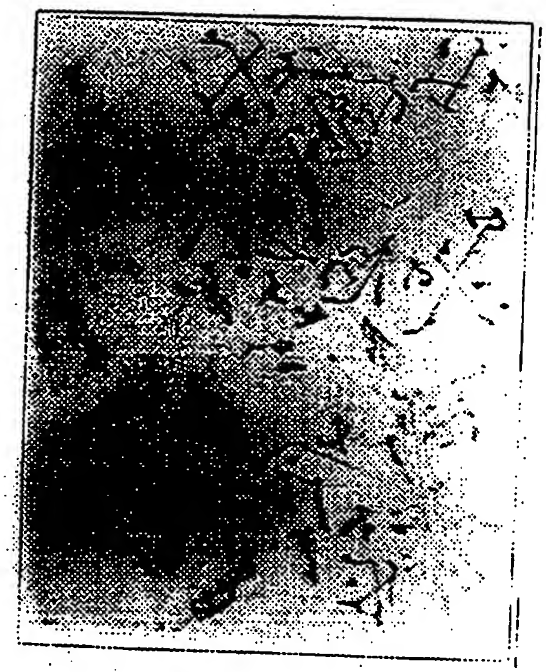


Fig. 3 (B)

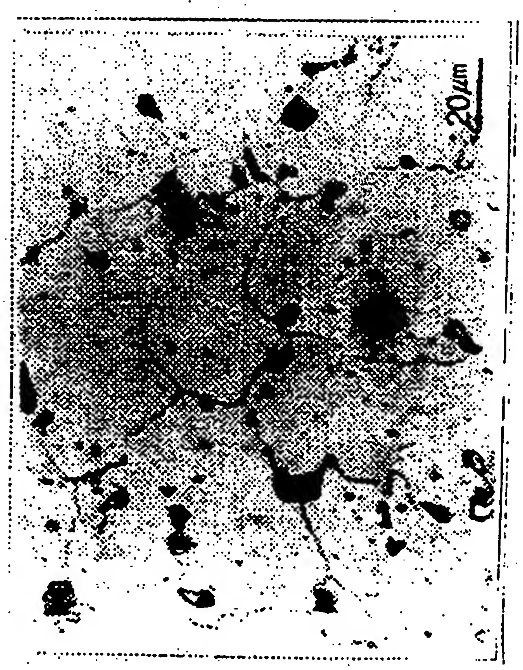


Fig. 3 (A)

Fig. 4